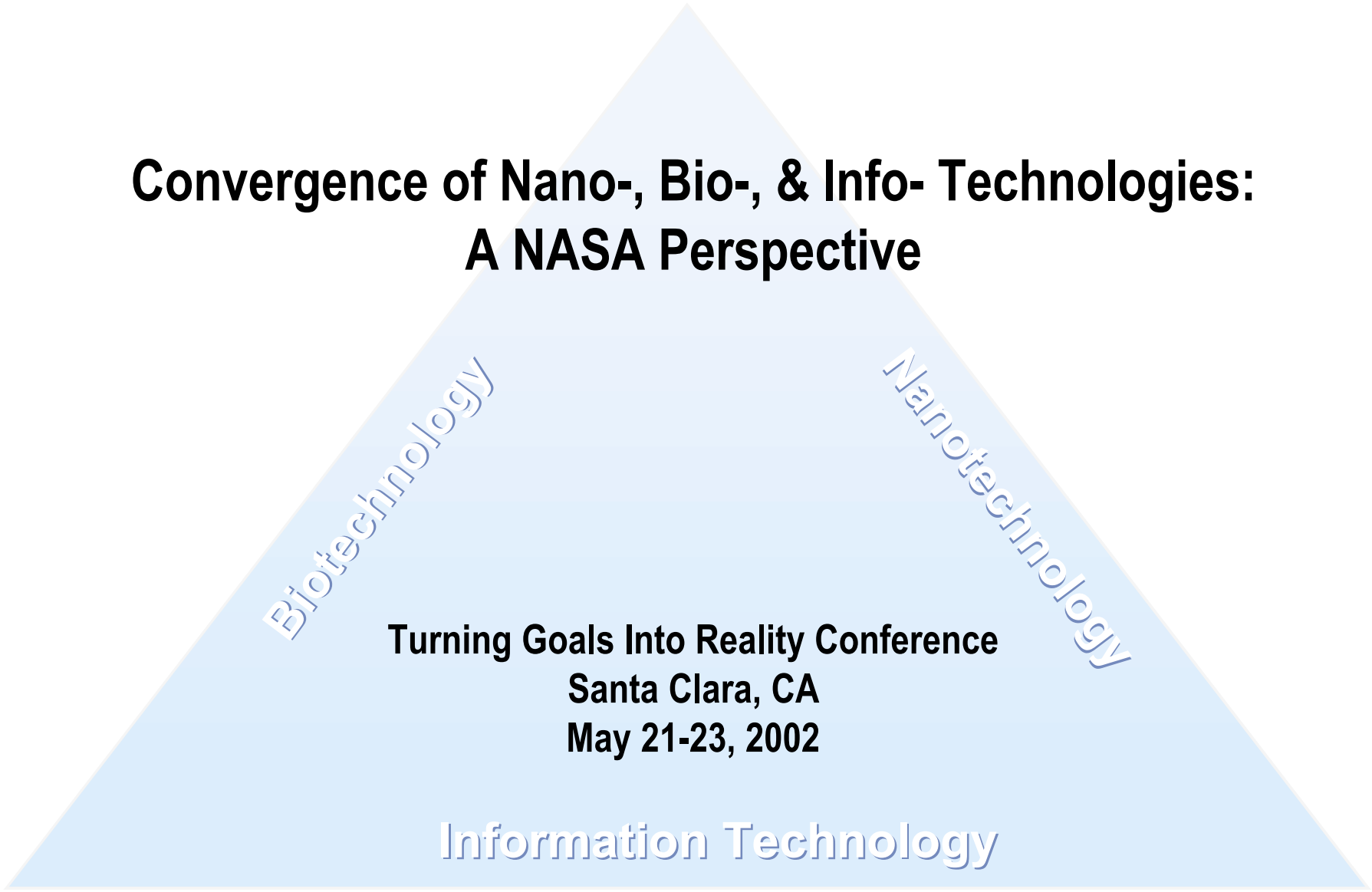
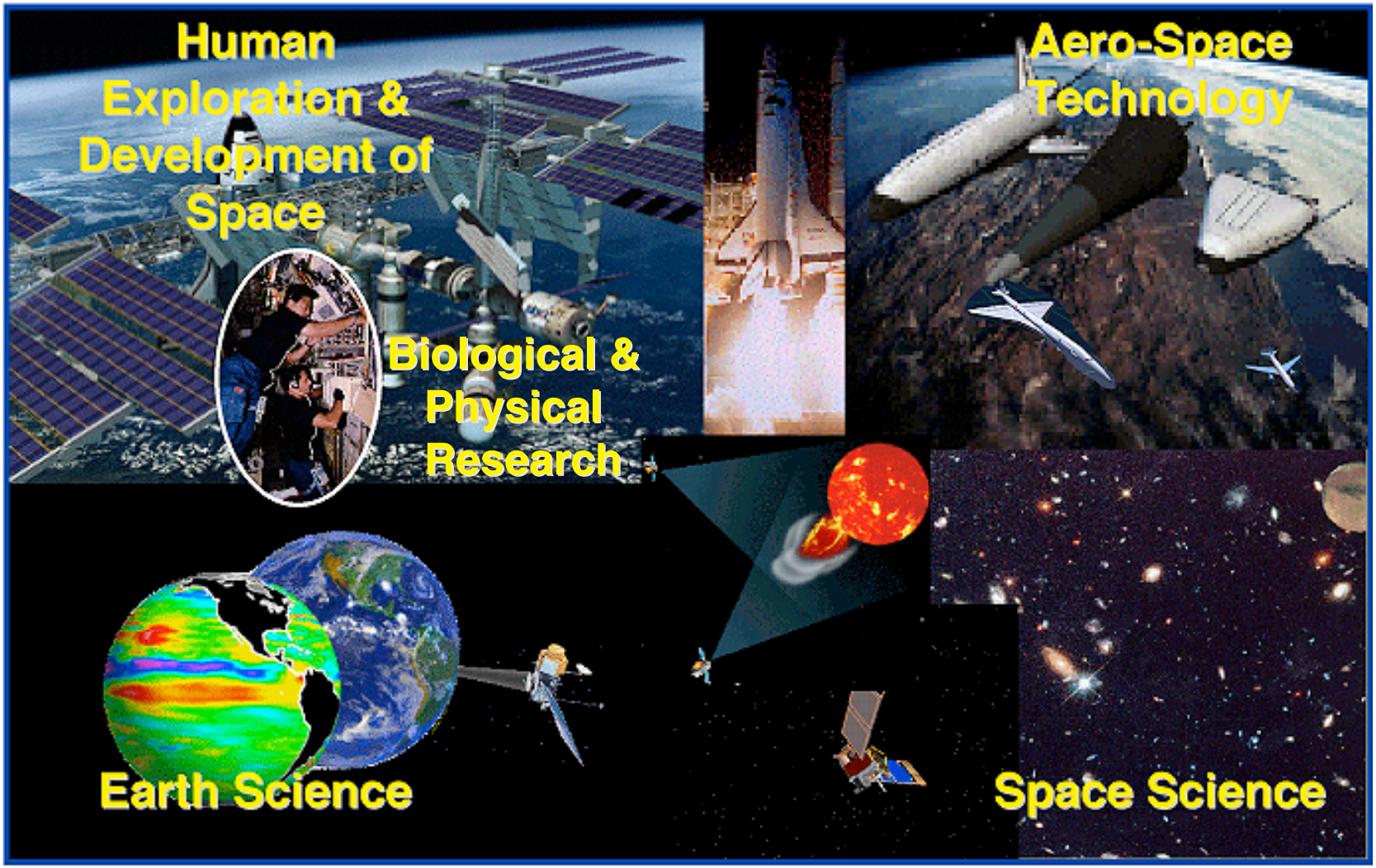
Convergence of Nano-, Bio-, & Info- Technologies: A NASA Perspective



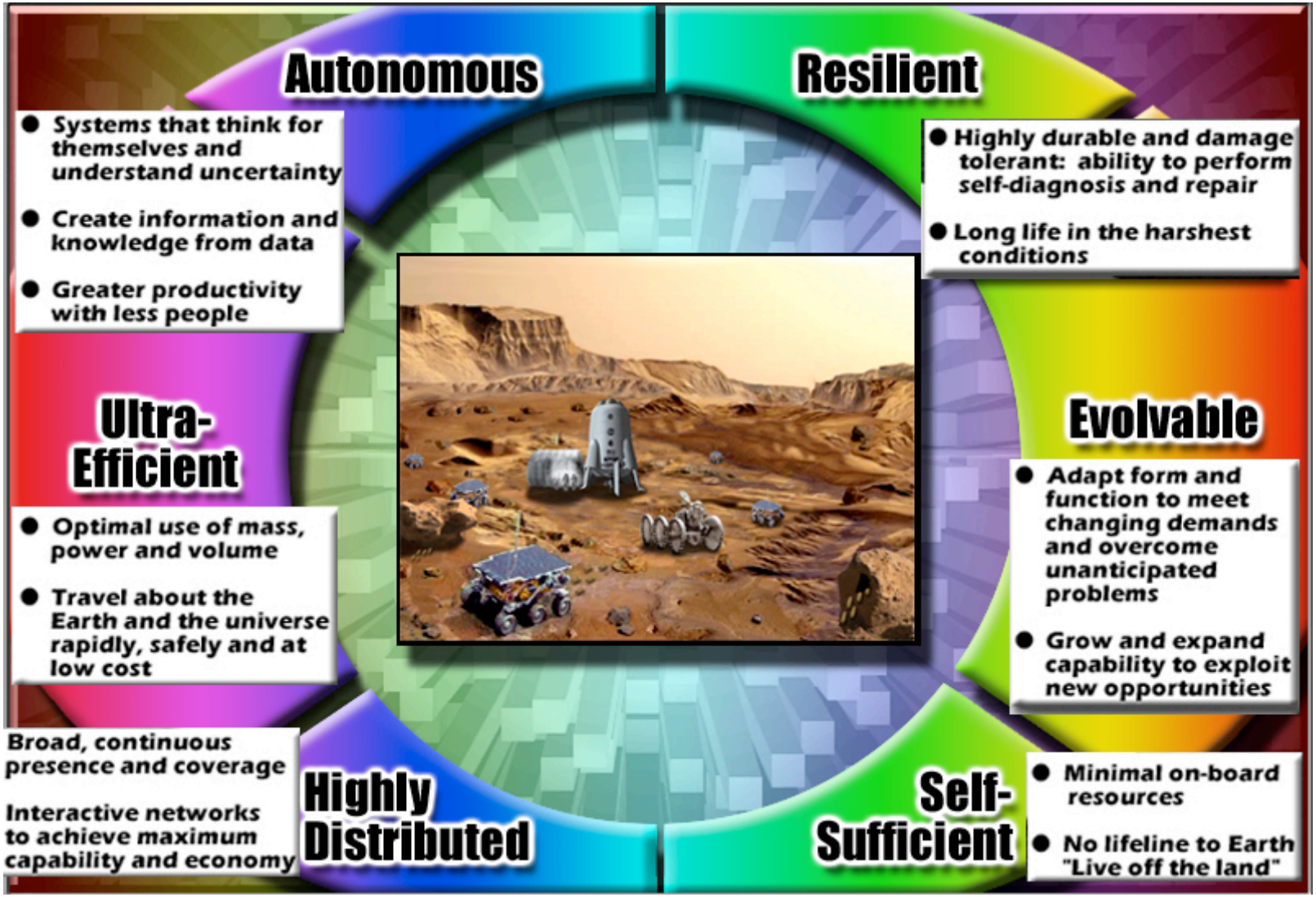
Turning Goals Into Reality Conference
Santa Clara, CA
May 21-23, 2002

Minoo N. Dastoor, Ph.D.
Office of Aerospace Technology
NASA

NASA's Strategic Enterprises

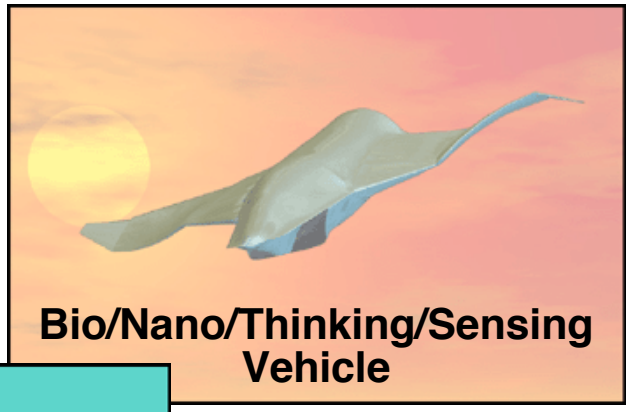


Goals for Future NASA Space Systems

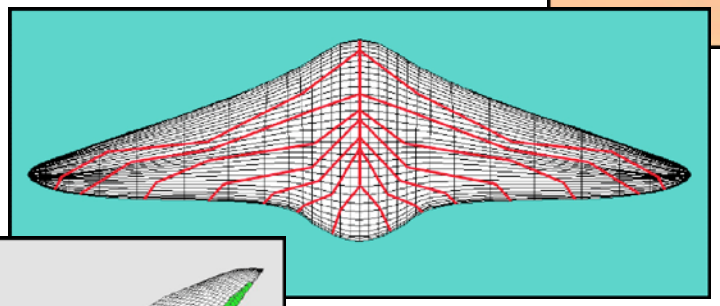


Towards Advanced Aerospace Vehicles: "Nature's Way"

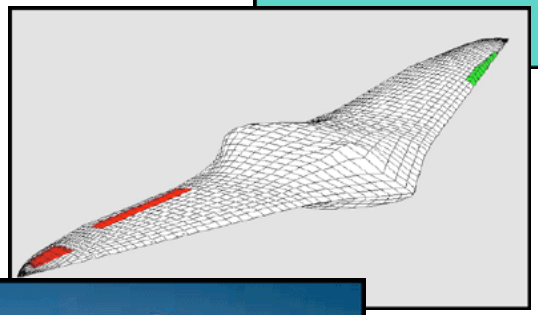
- Distributed self-assessment and repair
- Adaptive shape control
- Highly efficient propulsion
- Exploits Bio-Nano-Info technology revolution



Bio/Nano/Thinking/Sensing Vehicle



Self-Healing Structure with "Central Nervous System"



Smart Structure with Active Flow Control

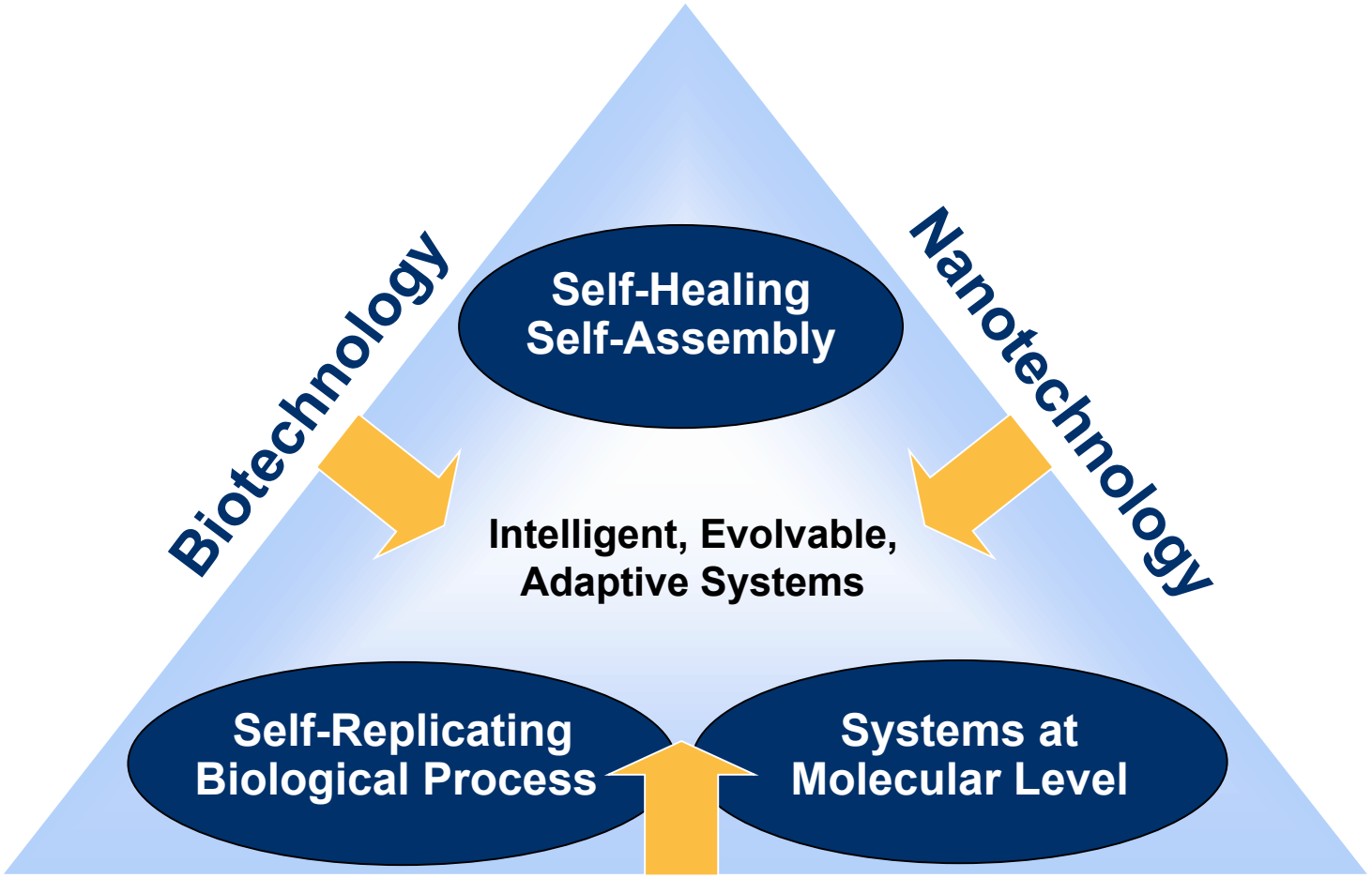
Modern Advanced Metal Aircraft

- Ultra Safe
- Whisper Quiet
- "Zero" Emissions
- Extreme Maneuverability
- High Survivability
- Ultra Low Fuel Burn

Advanced Technology Development

Time

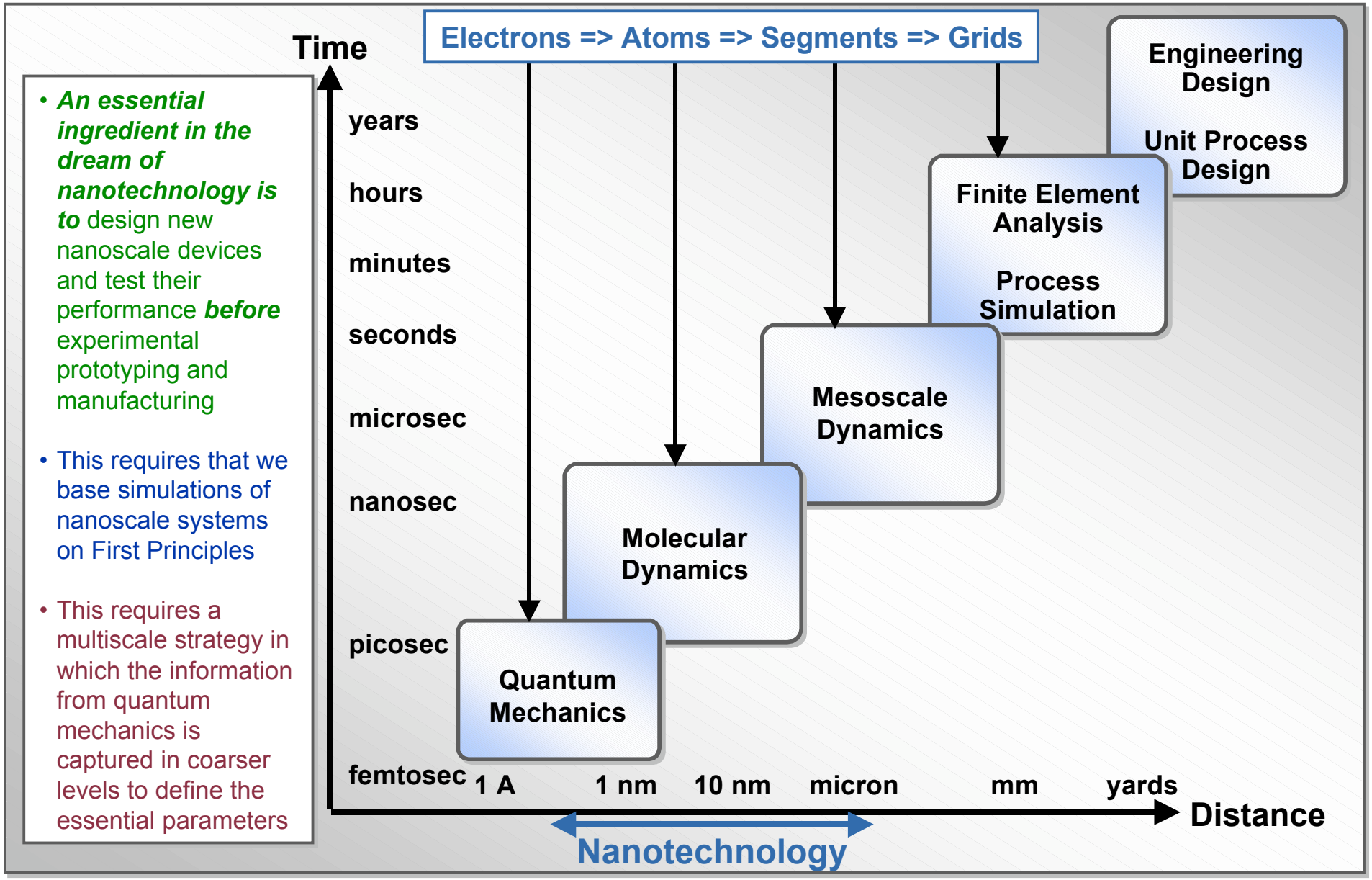
Revolutionary Technology Vision: The "Zone of Convergence"



Critical Nanotechnology Investment Areas

- **Nanostructured Materials ($10 M)**
  - High strength/mass, smart materials for aerospace vehicles and large space structures
  - Materials with programmable optical/thermal/mechanical/other properties
  - Materials for high-efficiency energy conversion and for low temperature coolers
  - Materials with embedded sensing/compensating systems for reliability and safety
- **Nano Electronics and Computing ($9 M)**
  - Devices for ultra high-capability, low-power computing & communication systems
  - Space qualified data storage
  - Novel IT architecture for fault and radiation tolerance
  - Bio-inspired adaptable, self-healing systems for extended missions
- **Sensors and Microspacecraft Components ($8 M)**
  - Low-power, integrable nano devices for miniature space systems
  - Quantum devices and systems for ultrasensitive detection, analysis and communication
  - NEMS flight system @ 1μW
  - Bio-geo-chem lab-on-a-chip for in situ science and life detection
- **University Research Engineering and Technology Institutes ($9 M)**
  - Bio/Nano-Technology Materials and Structures for Aerospace Vehicles
  - Nanoelectronics and Computing
  - Bio-Nano-Information Technology Fusion
- **Basic Nanoscience ($15 M)**
  - Biomolecular self-assembly and processing in space
  - Non-invasive diagnostic tools
  - Molecular signature for early detection
  - Tools for study of space-induced health effects

Multi-Scale Simulation Hierarchy



- ***An essential ingredient in the dream of nanotechnology is to*** design new nanoscale devices and test their performance ***before*** experimental prototyping and manufacturing
- This requires that we base simulations of nanoscale systems on First Principles
- This requires a multiscale strategy in which the information from quantum mechanics is captured in coarser levels to define the essential parameters

Barriers and Challenges for Nanotechnology

- **Production of nanomaterials**
  - Quantity, quality, control of properties & production in specified forms
- **Characterization at both atomic and bulk scale**
  - Fundamental mechanical, electrical and optical properties
- **Modeling & Simulation**
  - Prediction of physical/chemical properties and behavior from nanoscale to macroscale as well as models for material production
- **Applications Development**
  - Tools and techniques for applications of nanotechnology
  - Verification of predicted behavior/performance in actual environments
  - Systems Analysis to guide technology development